NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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REPORT NUMBER 1018

A TEST OF ELECTROLUMINESCENT PANELS FOR A HELICOPTER EMERGENCY ESCAPE LIGHTING SYSTEM

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Supported by a Contract with
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SUMMARY PAGE

PROBLEM

To determine the adequacy of a helicopter emergency escape lighting system composed of electroluminescent panels.

FINDINGS

Helicopter escape hatches outlined by electroluminescent panels are visible through turbid water at the distances and angles of regard specified by the Naval Air Development Center.

APPLICATION

This escape lighting system meets the specified criteria for visibility in a submerged helicoper and can be considered for adoption.

ADMINISTRATIVE INFORMATION

This research was conducted under Task N62269-82/WR/00232 with Naval Air Development Center, Warminster, PA. It was submitted for review on 9 Jan 1984, approved for publication on 16 Feb 1984, and designated as NavSubMedRschLab Rep. No. 1018.

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ABSTRACT

The effectiveness of a lighting system composed of electroluminescent panels and proposed for use in illuminating escape hatches was tested. It was visible to light-adapted subjects in turbid water at the distances and viewing angles required by the Naval Air Development Center.

INTRODUCTION

When a helicopter crashes at sea, this top-heavy aircraft tends to invert and quickly sinks. This leads to disorientation among the occupants; moreover, the water filling the cabin greatly reduces visibility,[1,2] and since the water is usually mixed with oil and other pollutants, vision is further degraded. The occupants, therefore, have difficulty finding the escape hatches.

The problem can be alleviated by installing lights around the escape hatches.[3] These lights should be visible at about 12 feet in turbid water at an angle of ±65° from a direct view, and a series of experiments indicated that the lights should be oriented in an inverted "U".[4]

This report presents the results of an underwater visual evaluation of one hatchset of the Helicopter Emergency Egress Lighting (HEEL) system designed by Luminescent Systems, Inc. (LSI) to meet the requirements in the HEEL development specification. The time to detect the presence of the lighted hatchset underwater by three observers was measured under various conditions corresponding to the above requirements.

SYSTEM DESCRIPTION

The LSI HEEL system design provides 3 or more light strips, one control box, and installation hardware for each emergency exit to be illuminated.

Each light strip consists of a flat electroluminescent core encased in a translucent fiberglass sheath which protects the core and provides structural rigidity. The light strip, approximately 14 inches long, is fastened to surfaces with brackets at each end and at the center. Three or more light strips suitably oriented around a hatch provide the required inverted "U" (with discontinuities between adjacent strips). A pigtail cable extending from one end of the light strip permits quick connection to the control box or to a cable which connects to the control box.

The control box contains a connector for each light strip cable. A manual switch on the control box permits the light at an emergency exit which is blocked by cargo or special equipment to be locked out prior to flight. Another connector accepts the plug-in wiring of the remote HEEL deactivation and the arm/disarm functions controlled by the crew. When the system is armed and not manually locked out, reduction of the deactivation signal voltage to less than 10 VDC automatically illuminates the light strips. A battery within the control box supplies all the necessary power.

TEST CONDITIONS

The degree of visibility of underwater lights is primarily determined by four factors on which the HEEL specification was based.

<u>Intensity</u>: The more intense the light, the more likely that the observer will detect its presence. Since constraints of power and weight

will, in practice, limit the intensity, it is desirable to produce only the intensity which is required. Previous experiments have determined the intensity requirements for the conditions which are likely to be encountered.[5,6]

Viewing distance: The farther the distance between observer and light, the greater the probability that the light will not be seen. On a typical helicopter troop carrier, the farthest distance between escape hatch and passenger is approximately 12 feet. This, then, is the approximate distance at which an escape light should be visible. The distance between the HEEL light and the viewer in this evaluation was 13 feet, roughly representing worse case conditions.

Turbidity: As the water in which the lights and observers are immersed becomes more turbid, it becomes more difficult to see the lights. The turbidity of the water found under "natural" conditions varies through the entire range of possibilities from clear to opaque. Although ocean water is relatively clear, the water found inside a helicopter which has crashed in the ocean may be very turbid because of leaks of fuel, oil, and debris. There are reports from crash survivors that visibility may be no better than 2 or 3 feet. The visibility of the lights was tested in water of three turbidities. At the lowest turbidity, a high contrast grid target was visible at 13-14 feet, equivalent to $\alpha = 0.9$; at the intermediate turbidity, it was visible at 8-9 ft ($\alpha = 1.67$); and at the highest turbidity, it was visible at only 3-4 feet ($\alpha = 4.0$).

Adaptation: The state of light or dark adaptation of the observer is also critical. Observers who are completely dark-adapted will, of course, be able to detect lights which are much dimmer than will observers whose eyes are adapted to a very bright light-level. Men on helicopters may be in any conceivable state of adaptation when a crash occurs; if it happens at night, they may be almost completely dark adapted; during the day, they may be adapted to the most intense light levels found in the summer sky--10,000 foot-Lamberts. For the purpose of this evaluation, it was assumed that if it were a bright day, there would be daylight coming through the hatches even when they were submerged. On the other hand, it seemed prudent not to evaluate the lights in the best possible condition, when the subjects were dark adapted. An intermediate level of light adaptation, 100 ft-L, was therefore chosen. This light level is that of a well-lighted room, but it corresponds to a somewhat overcast day out-of-doors.

METHOD

The evaluation was carried out using a trough 14 feet long, 30 inches wide, 30 inches deep, and lined with black plastic. Lights were placed at one end, and the subject immersed his head at the other end and looked down into a mirror which reflected a view of the lights (Figure 1).

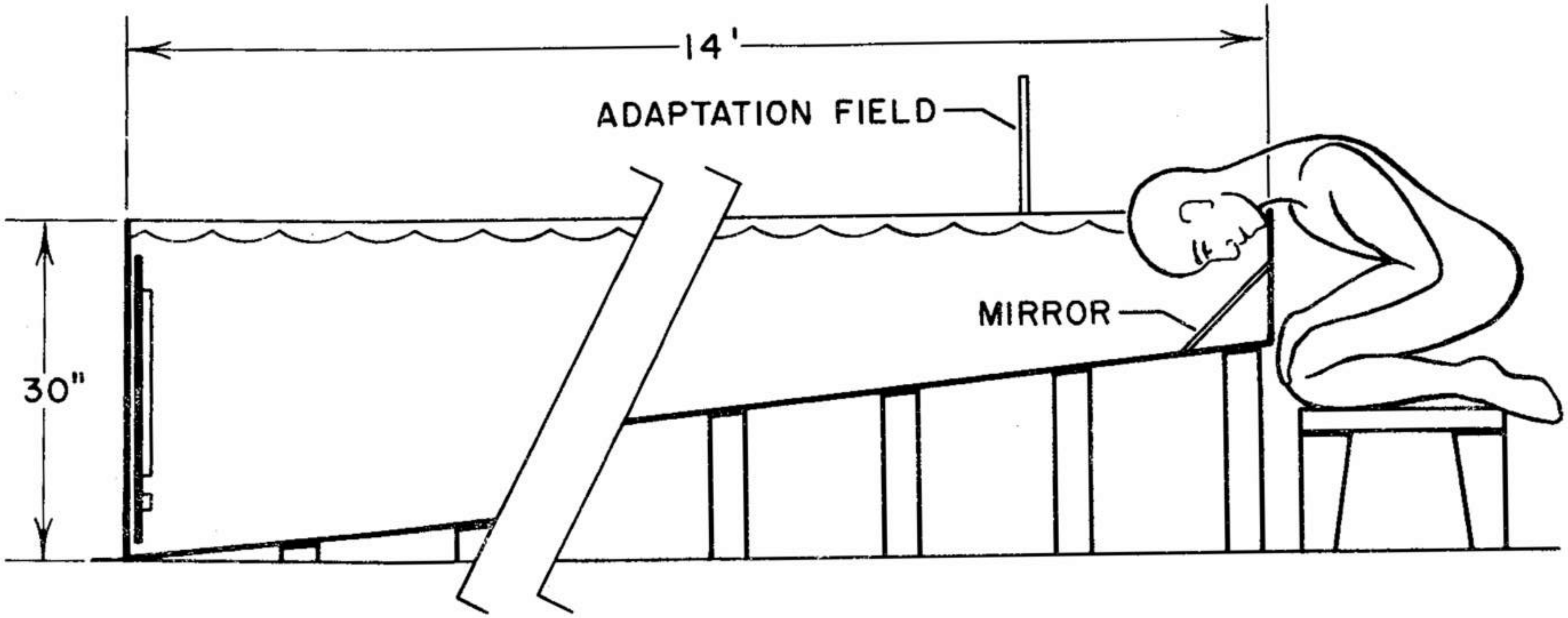

Fig. 1. Diagram of the experimental trough. The adaptation field was illuminated to 100 ft-L.

The frame on which the lighting configurations were mounted was about 28 inches square and could be immersed so that the subject was looking directly at the frame (a "normal" view or a viewing angle of 0°), or was looking at the edge of the frame (a viewing angle of 90°), or at intermediate angles of 45° or 65° from the normal. The purpose was to obtain responses at various viewing angles, since it is unlikely that all crew members will be looking directly at an escape hatch during an emergency. The viewing angle of 65° was specified as the maximum viewing angle at which the lights must be visible. Tests were also conducted at a 90° viewing angle, but they are of questionable practical significance and are recorded only for informational purposes. However, for the moderately turbid and clear conditions, it was immediately obvious that the light could be seen at the extreme viewing angle of 90°. There was no question, then, that they would be visible at a viewing angle of 65°, and therefore, no data were taken at 65°.

Subjects: Three staff members of the Naval Submarine Medical Research Laboratory served as subjects. Their ages were 53, 30, and 27. All had had experience as observers.

Procedure: The time taken to detect the light was the response variable measured in this study. At the start of each run the subject was light-adapted. A white card about 18 inches square was mounted immediately in front of the observer and illuminated to 100 ft-L. Between each trial, when his eyes were not under water, the observer gazed at the card. When he was ready to make his observation, the adaptation light was turned off and he immersed his head in the water with his eyes closed. The target lights were turned on, the subject opened his eyes and started a stop watch; when he detected the presence of the light in the water, he stopped the watch, ending the trial. He took his head out of the water and once again looked at the adaptation field until the next trial began.

The turbidity of the water was set as follows. A high contrast grid target, 9 x 14 inches, with black and white stripes 2 inches wide, was immersed in the water, illuminated so that the white stripes reflected 100 ft-L, and viewed by an observer wearing a facemask. Increasing turbidities were obtained by adding corn starch to the water until the target could be detected at the desired distance but disappeared when the viewing distance was increased by 1 ft.

The visibility of the test target was checked after each subject had completed each condition, or every 15 minutes if there were delays in the testing.

The three turbidities were tested in order of increasing turbidity for each subject. At each level of turbidity, the light angle was randomly presented to each viewer. The viewers were also frequently presented with catch trials of "no light". Each viewer was tested at least four times at each combination of turbidity and viewing angle,

but additional data points were obtained under some conditions.

RESULTS

The occupants of a helicopter will not only lack facemasks, they will also not have any scuba equipment. The amount of time they have to escape from the submerged aircraft will be limited, therefore, by the amount of time they can hold their breath. It is doubtful that the men will be able to hold their breath much longer than 90 seconds. It seems prudent to assume, therefore, that the escape hatch must be seen within 30 seconds, leaving another 30 to 60 seconds to get through the hatch and rise to the surface. On the other hand, it would seem that differences in visibility-times less than 30 seconds are not critical.

All the data are presented in Table I. Figure 2 shows the mean response times (RT) as a function of viewing angle. Figure 3 gives the ranges of RTs for each subject under each condition.

Mean response times and variability increased with turbidity and viewing angle; even at the highest turbidity and a viewing angle of 65° (the largest viewing angle in the specifications), the mean response time was about 3 seconds, and the highest response time was less than 10 seconds.

Much more data were collected at the highest turbidity than at the lower turbidities for two reasons. One was the greater variability typically found under more difficult viewing conditions. Second, one of the subjects (S2) reported that he could hear the 2000 Hz hum emitted by the control box when the lights were activated. He believed he was responding to the tone rather than to the light. The two younger subjects were then retested with ear protectors. (The oldest subject could not hear the hum.) Both sets of results are presented in Table I. The subject who had been aware of the hum, however, improved his performance with the ear protectors, suggesting that he may have been delaying his response in order to listen for the hum. The response times of the second subject, who had not been paying attention to the hum, were longer with the ear protectors. The increase in response time ranged from 3 to 5 seconds for the viewing angles 0 to 65°, a difference of no practical significance. It may also be noted that the response times without the ear protectors increased with increases in viewing angle; this would not be the case if the subjects were simply responding to the tone. Since there were no systematic changes, both sets of trials were included in the analysis.

In conclusion, these lights can be seen under combinations of turbidity and viewing angle. It is clear that they meet the visibility requirements that were set. They are visible to all the subjects at a distance of 14 feet through water whose turbidity approximates that of harbors, and the visibility of the lights is not appreciably degraded as the viewing angle diverges from the normal by as much as 65°.

TABLE I. LIGHT DETECTION TIMES AT VARIOUS ANGLES AND TURBIDITY LEVELS

Visibility = 15 ft:: Turbidity α = .9

0°			45°			65°			90°			
S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
.69	.67	.53	.85	1.26	.56				1.12	3.00	10.46	
.55	1.00	.63	.64	.85	.51		Not tested		1.80	1.02	.89	
1.22	.71	.46	1.20	.50	.66				.81	.90	7.35	
.82	.81	.64	1.25	.63	.59				1.97	1.35	7.06	
.82	.79	.56	.98	.81	.58				1.42	1.57	6.44	Mean
	.72			.79						3.14		Group $\bar{X}$

Visibility = 8 ft:: Turbidity α = 1.67

1.68	.65	.86	1.07	1.15	.76				3.07	5.47	12.52	
.66	.72	.80	1.37	1.42	.76		Not tested		5.15	3.21	18.34	
.93	.39	.84	.67	.36	1.39				5.10	6.12	17.40	
.92	.49	.62	1.14	.43	1.04				5.91	4.06	21.66	
1.04	.56	.78	1.06	.84	.98				4.80	4.71	17.48	Mean
	.79			.96						8.99		Group $\bar{X}$

Visibility = 3 ft:: Turbidity α = 4.0

2.46	1.52	4.91	2.00	1.28	4.62	1.89	2.28	3.67	13.98	10.86	11.75	
1.32	.50	3.36	1.65	2.53	6.35	4.32	.96	4.26	4.35	8.46	9.73	
2.17	1.50	2.84	2.42	.49	5.52	1.96	2.99	2.52	7.42	4.78	12.30	
1.48	.61	2.00	2.24	.63	2.63	3.31	.59	3.68	17.11	3.77	8.66	
6.03*	1.28*		5.92*	.55*		4.12*	.71*		14.96*	1.25*		
8.60*	.53*		4.80*	1.26*		3.78*	1.48*		9.72*	3.32*		
8.50*	1.39*		8.18*	.75*		9.78*	.96*		21.17*	3.48*		
6.10*	1.96*		4.44*	.66*		6.23*	.88*		34.46*	1.23*		
4.59	1.16	3.27	3.95	1.04	4.78	4.42	1.35	3.53	15.39	4.64	10.61	Mean
	3.00			3.25			3.02			10.21		Group $\bar{X}$

* These trials were run using a set of ear protectors to block sound to observer.

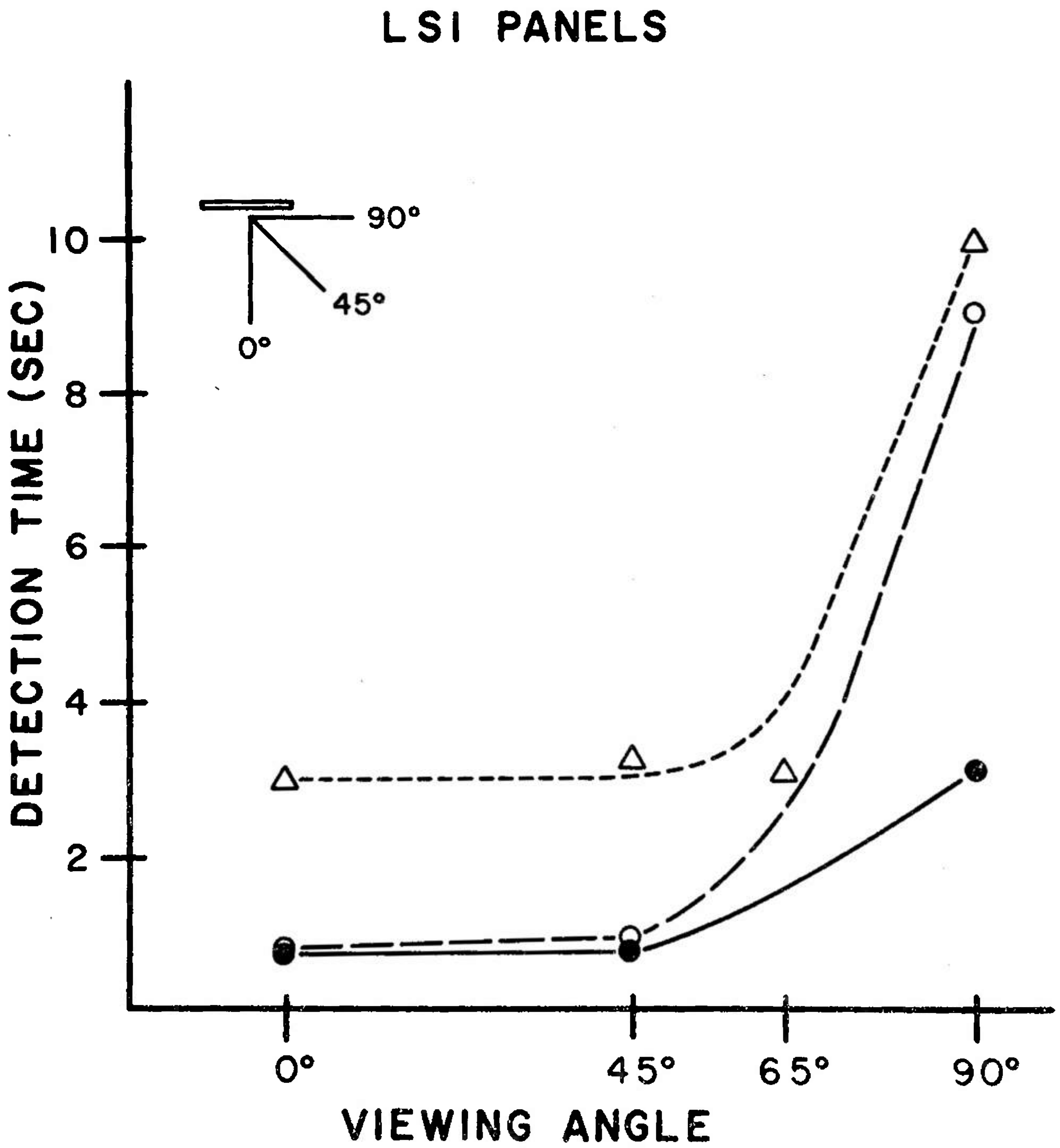

Fig. 2. Mean detection times for various viewing angles of the lighting configuration in water of low (o), medium (O), and high (Δ) turbidity.

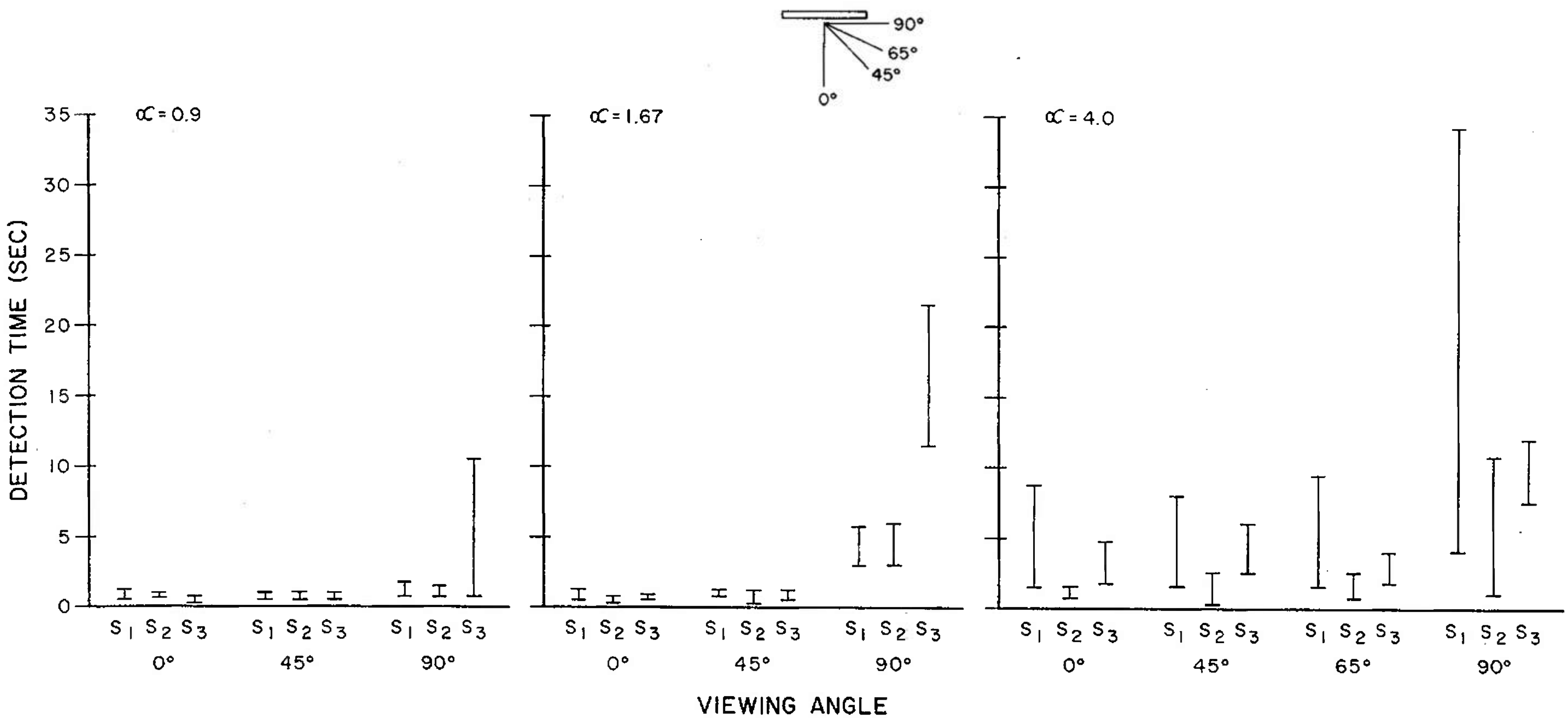

Fig. 3. Detection times for each subject under the various conditions.

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The effectiveness of a lighting system composed of electroluminescent panels and proposed for use in illuminating escape hatches was tested. It was visible to light-adapted subjects in turbid water at the distance and viewing angles required by the Naval Air Development Center.